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For The Atomic Energy Commission

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MATERIALS TESTING REACTOR PROJECT
QUARTERLY REPORT

For Period Ending June 1, 1950

Prepared by J. R. Huffman, Project Engineer

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MATERIALS TESTING REACTOR PROJECT
QUARTERLY REPORT

For Period Ending June 1, 1950

0.0 SUMMARY

Progress during this quarter has been on schedule. All basic design data, with the exception of some details of instrumentation and control networks, have been transmitted to the Blaw-Knox Construction Company. A large number of detailed decisions and approvals have been made. Blaw-Knox estimates the design to be 45% complete.

A gravel road to the site has been put into use, and rough grading of the Materials Testing Reactor area is well along. The second production well is half drilled. Contracts are about to be let for some of the service buildings. A contract has been signed with Fluor Corporation, Limited. Construction buildings are underway, and the excavation for the reactor building has been started. Procurement of critical items of material and equipment has continued.

A revaluation of the anticipated progress schedule postponed the date for enclosing the reactor building to December 1, 1950. The over-all completion date of December 1, 1951 was not changed. Drawings and specifications of the reactor building and canal foundations, steel structure, and specifications of the elevators and cranes have been approved. A considerable amount of work has been done on the laboratory wing and its installed equipment. Steel for the reactor and reactor building should be delivered on schedule.

As requested by the Atomic Energy Commission, site facilities have been cut to not exceed a cost of \$18,000,000. A portion of the laboratory wing and the reactor service building and warehouse have been eliminated and the site area has been reduced. These deletions have required additional design studies but did not appreciably delay progress on any critical items.

The canal has been lengthened to provide adequate storage capacity to conform with the anticipated chemical plant completion date. Many other details of the canal design have been established. Blaw-Knox has progressed on the designs of the fuel assembly discharge chute, transfer mechanism, the canal saw and the storage facilities.

Complete information on the air system has been transmitted to Blaw-Knox. The stack height has been set at 250 feet to be constructed of concrete. The filter beds have been eliminated. Concrete pipe will be used for the air duct outside of the reactor building.

The designs of the water systems, the retention basin and effluent control system have been established. The flash evaporators and critical sizes of stainless steel pipe are on order.

Studies of process instrumentation, reactor control network, and instrument and control room layout are nearing the final stages of agreement. All factors affecting the construction schedule of the reactor building have been acted upon. Work on health-physics instrumentation has been initiated.

Blaw-Knox is progressing on the designs of the beam hole liners, radiation doors and shields, the coffin and coffin carrier and on the service facilities. Procurement was initiated for the graphite and beryllium needed for the main beam hole dummy plugs.

The designs of the electrical power and communication systems have been established. There is still concern over the reliability of the local power supply.

A significant change in shielding has been effected by an increase in the canal depth from 17 to 18 feet. The arrangement of the cooling holes in the beryllium plugs has been altered to decrease anticipated thermal stress. Water activity calculations have been completed in order to facilitate progress in effluent control and instrumentation. Preliminary calculations are being made to determine the optimum decay time of the process water activity that will yield maximum instrument sensitivity for the detection of a fuel plate rupture in the main water stream.

1.0 STEERING COMMITTEE REPORT

1.1 Estimated Costs

The estimated cost prepared by the Chemical Plants Division of Blaw-Knox Construction Company on January 9, 1950, for the construction of the project was \$19,678,000, including contingencies. With the engineering, inspection, general contractor's fee, work outside fence, and some small miscellaneous items, the total came to \$22,315,000, and was carried at \$23,255,000 by the addition of another contingency fee by the Idaho Operations Office. Because of this high estimate, the Atomic Energy Commission requested that the project be reduced in size and kept within a limit of \$18,000,000.

In order to do this, even though inadequate facilities had already been planned, further reductions were made to meet the new limit. Also, items were dropped which are necessary for efficient operation and for efficient use of the reactor facilities. However, the reactor can be placed in operation and limited use made of its experimental facilities with the additional facilities to be constructed later as required.

The reductions in cost were accomplished in several ways:

- a. By reducing early estimates of cost of inspection, main contractor's fee, and contingencies.
- b. By deferring the construction of certain experimental facilities until after the reactor is operating. Included are: all but one of the coffins, the shielding facility, the pneumatic shuttle system, and a large part of the laboratory equipment and furnishings.
- c. By arbitrarily cutting down laboratory, office and service space through elimination of the reactor service building, the warehouse, and the tips of the laboratory wing.
- d. By taking advantage of several design economies made in the interim between estimates, which included reduced floor loadings in the reactor building, use of stainless clad instead of solid stainless steel water pipe, reduced estimates on canal facilities and coffins, reduced demineralizer capacity, elimination of water filters, placing of demineralized storage tank on the ground, reduction of number of boilers, reduction of the number of wells, reduction of stand-by power, decrease in size and number of retention basins, elimination of several diesel stand-by units, elimination of the air supply building, and the removal of air filters.
- e. By reducing the fenced-in area, a substantial saving in the cost of grading, fencing, lighting, roads, and underground piping was effected. The parking lot was made smaller, and the railroad siding eliminated entirely.
- f. By relegating several services to the Reactor Testing Station Central Facilities, including the automotive building, shop facilities, and the cafeteria.

An increase in estimated cost of the beryllium for the reflector has occurred due to more accurate production estimates. This has raised the estimate from \$566,000 to \$1,000,000. Also, a one-ton crane has been added in the reactor building, and the canal has been extended to provide more storage area.

With all these changes and the use of reasonable contingencies, the project is estimated to cost \$17,990,000.

It should be pointed out that the reduction in some of the facilities for the MTR will require a corresponding increase in the Central Facilities area, so the saving in funds is not as real as it may appear. Considering the loss of efficiency taken by the project, the reduction may not be justified.

1.2 Construction Contracts

The Idaho Operations Office has signed a cost-plus-fixed-fee construction contract with the Fluor Corporation, Limited, of Los Angeles, for almost all major items that are part of the process system, i.e., reactor structure, reactor building and laboratory wing, process water system and process air system. The separate building units such as the steam plant, sewage disposal plant, wells, retention basin, working reservoir, raw water reservoir, sub-station, fences, fence lighting, safety and security building and the control houses will be constructed by others on fixed bids.

1.3 Progress at Site

The preliminary surveys to be made prior to construction have been completed. These included land surveys, core drillings, load carrying tests, and water permeation tests.

The contract for grading and building the construction road has been awarded, and this work has been nearly completed.

The well contractor has completed the first production well, drilling to a depth of 600 feet, with the water level at 456 feet. A pumping test of 21 hours was made at 1,150 gpm with a draw-down of only 0.5 feet. The second well is being drilled and has reached a depth of 215 feet.

At the present time the Fluor Corporation is erecting its construction buildings and grading the area. Actual excavation for the reactor building started May 15.

1.4 Progress of Design

The conceptional design of the reactor has been essentially completed. The detailed design of the reactor core components is progressing at Oak Ridge National Laboratory. The drawings for sintering the beryllium have been released, and the drawings for machining are being prepared.

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The Blaw-Knox Construction Company has nearly completed the flow or process drawings of the entire project. The detailed construction drawings for the reactor building have been released for the excavations and the foundations. The detailed steel drawings will be released for procurement in time for the steel erection to start the latter part of August.

The engineers at Argonne National Laboratory have completed the conceptional designs of the project facilities, except that some details have not been settled.

1.5 Procurement

Procurement of the reactor components has been started by ORNL. At present the beryllium is being produced, the beryllium sintering and machining has begun, contracts for the reactor tank and castings are being let, and preparations are being completed for the machining of the graphite.

Some procurement has been done by Blaw-Knox. The reactor building crane and the flash evaporators have been ordered. The Fluor Corporation has taken over the procurement of and are starting actively to purchase pumps, pipe and smaller items. The steel for the reactor structure and reactor building has been ordered by Blaw-Knox and Fluor. Delivery is expected in August.

1.6 Experimental Work

The mock-up critical experiments are progressing very satisfactorily at Oak Ridge. Completion of these tests is expected by July 1.

Data which became available in March from the irradiation tests at Hanford seem to indicate that radiation damage to the clad uranium-aluminum alloy plates is levelling off at radiations equivalent to 15 days in the MTR. This indicates that 30-day irradiation periods in the MTR are quite possible. Arrangements have been made for irradiation of a complete fuel assembly in the Chalk River reactor beginning July 1, 1950. This will give a final check on the effect of irradiation damage.

2.0 DESIGN

The major emphasis at ANL during this period has been directed toward checking and approving Blaw-Knox flow sheets, layouts, drawings, specifications, requisitions and conference notes. All flow sheets, except for instrumentation, have been approved. Layouts and construction drawings of the site plan, the safety and security building, the control houses and the reactor foundations and reactor building have been approved.

Layouts of the laboratory wing and steam plant have been in active study. Numerous specifications and requisitions for mechanical equipment such as pumps, motors, cranes, elevators, and tanks have been checked and approved.

2.1 Plot Plan

The economies discussed in Section 1.1 have produced substantial changes in the plot plan shown as Figure 1 (Drawing BKC-3150-91-5, Rev. 1) in the September-October-November Quarterly Report (ANL-4402). The modified plan is presented in Figure 1 of this report (Drawing BKC-3150-91-5, Rev. 3) which shows the bare minimum of facilities needed to prove that the reactor will perform satisfactorily. The tips were removed from the laboratory wing. The automotive building, reactor service building, warehouse, and hot materials burial were eliminated from the initial construction plans. The cafeteria building was reduced in area from approximately 6,500 square feet to 800 square feet and will serve merely as a canteen. The electrical sub-station was moved closer to the water reservoirs. With this change it was possible to reduce the site area from approximately an area 2,900 feet by 1,900 feet to an area 1,100 feet by 1,700 feet.

Although initially, construction will be as outlined in the reduced site plan, it is planned to add some of the eliminated facilities in the future. The first expansion would be to construct the reactor service building, the warehouse, and the tips on the reactor wing. The addition of the reactor wing tips would be expected within a year after the reactor operates successfully. The service building and warehouse would be added at the same time or slightly later depending somewhat on the volume of experimentation and the efficacy of usage of central machine shops and storage facilities. Service facilities to these future additions will be provided at the respective positions in the initial construction period if not too costly. Main header lines and service lines will be so sized that these additions can take place without difficulty during future construction of piping and buildings.

The steam plant will be made large enough initially to handle all facilities shown on drawing BKC-3150-91-5, Rev. 3 plus the future tips on the reactor wing, the service building, and the warehouse. Space will be allowed in the plot for possible future addition of the filters to the reactor exhaust-air system at the fan house which have been eliminated from the present design.

Additional future expansion will probably consist of the following: administration building, second laboratory wing, cafeteria, maintenance building, hot laboratories and extensions to the demineralizer building, cooling tower, and boiler house. These future expansions have been considered

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in the layout of the site plan. With these expansions the site plan area will undoubtedly increase to that shown on drawing BKC-3150-91-5, Rev. 1. In the initial construction period, however, no provisions are to be made for these additions.

2.2 Reactor Building and Wing

2.21 Reduction in Size of Wing and Detailed Progress

Due to the need for elimination of some of the site facilities, the floor area in the reactor wing was reduced. The south and north portions of the tee-shaped building were eliminated, leaving a rectangular-shaped wing 128' wide by 141'6" long. With the reduction of the wing, the following facilities were deleted: library, records storage, conference room, drafting room, two 24' x 30' laboratories, two 12' x 30' laboratories, two engineers' offices and eight other offices. Since all of these eliminated facilities were planned for later conversion to laboratories, this reduction was essentially an elimination of future laboratory space.

The wing as now conceived will consist of those facilities which were not affected by the change and five 24' x 30' laboratories, four 12' x 30' laboratories and two 12' x 15' offices. The main machine shop area will be somewhat increased in area. The wing will have a full basement. Ventilating equipment, electric switch gear and main service valves and header lines for both the reactor building and the wing will be located in the wing basement. The building will be so constructed that the north and south portions of the tee design can be readily added.

Blaw-Knox has made studies of machine shop and laboratory layouts. Specifications are being prepared for machinery and equipment for these facilities. It has been decided to equip initially and fully four 12' x 30' laboratories and one 24' x 30' laboratory. Two 24' x 30' laboratories will have services piped in but will not be equipped. Two other 24' x 30' laboratories and one 12' x 30' laboratory will have provisions for service piping, but the piping in the laboratories will not be installed.

A study has been made of the floor loadings in the wing. Live floor loadings have been established as follows:

Four 12' x 30' laboratories for the pneumatic shuttle system	250 lbs/sq.ft.
Three 24' x 30' laboratories for shielded hoods or caves	500 lbs/sq.ft.
Staff Shop	250 lbs/sq.ft.

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Machine Shop	500 lbs/sq.ft.
Stores, shipping and receiving	250 lbs/sq.ft.
Corridors leading to machine shop, 24' x 30' laboratories and shipping and receiving room	250 lbs/sq.ft.
All other areas	150 lbs/sq.ft.

Drawings showing foundations and building steel for the wing will be ready for ANL comments and approval very shortly.

2.22 Elimination of Reactor Service Building and Disposition of Plug Storage

With the elimination of the reactor service building from the initial construction plans, it was necessary to reevaluate the facilities required in the wing machine shop, to reconsider the plug storage facilities, to relocate the vault for storage of new assemblies, and to provide an alternate location for making preparatory experimental setups. For the start-up, Central Facilities will endeavor to fulfill the MTR machine shop needs in excess of the amount which can be accomplished in the wing machine shop. The vault has been relocated in the basement of the reactor building. Operations testing work will be kept to a minimum and will be set up in the reactor building. Final plans for plug storage have been deferred for a period of six months. However, a preliminary study of plug storage has been made, and it is planned to reduce this facility to a 30' x 40' block located outside the reactor building. The construction and location will be such that there will be little difficulty in adding to the storage capacity and no interference with the future erection of a service building will result.

2.23 Reactor Building Progress

Structural steel for the entire reactor building has been sized. Drawings showing the steel layout have been made by Blaw-Knox and approved by ANL. Specifications and mill orders have been prepared by Blaw-Knox and forwarded to the steel fabricator for rolling and detailing. Specifications for bids on the two elevators, the 30-ton and one-ton overhead cranes and the two-ton canal crane were written and approved. Vendors for these items have been selected and requisitions have been placed. To allow immediate excavation for the reactor building foundations, drawings showing all necessary excavations and concrete sub-structures have been made and approved. These same drawings will be rechecked and more fully detailed so that the pouring of concrete can take place immediately following excavation. It is the hope of the MTR groups and Blaw-Knox that by November 15 of this year, the concrete sub-structure will be poured, all the steel will be

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in place, and the building will be enclosed so that inside work can continue during the winter months. It is possible that work will not be far enough advanced to permit pouring of the roof slab, in which case the roof purlins will be put in place and the roof structure braced sufficiently to permit construction of the walls and a temporary roof.

2.24 Ventilating Equipment and Air Inlet Location

The ventilating equipment for both the wing and the reactor building will be located in the basement of the wing.

The air intake was planned to be located at the top of the reactor building, but after a more detailed study was made, it was decided that an air intake near ground level would be more satisfactory. The ground level location will minimize the possibility of contamination from radioactive gases and particles from the main stack and fumes from the laboratory hood exhausts. The location of the air intake is now south of the wing structure approximately 15 to 20 feet away from the building. The intake duct will run underground, beneath the wing basement floor to the air filters to the electrostatic precipitators, both of which are located in the wing basement.

2.25 Temporary Buildings

A request was made to the building contractor to construct the contractor's administration building, service building and shop building semipermanent, and that these buildings remain on the site after the completion of the MTR. Most of the administrative services which were to be located in portions of the wing will be located in the contractor's administration building. The shop building will be used for the pipe shop, tin shop, carpenters shop and miscellaneous facilities for which no permanent provision has been made under the initial construction program.

2.26 Degrees of Activity

The degree of activity in the subpile room has been set at 0.1 r/8 hrs at the shield surface. The degree of activity in the monitoring room has been set at 0.01 r/8 hrs.

2.3 Canal and Canal Facilities

2.31 Changes in Depth, Length and Overhead Road Construction

Calculations for attenuations of fission product gammas had indicated that 17 feet of water would be needed in the spent fuel storage section of the canal. Recent Oak Ridge experiments gave results showing higher fission gamma energies and lower attenuations for a thick layer of

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water than those used for previous calculations. Consequently, the main canal water depth has been increased to 18 feet to provide 0.01 r/8 hours at the surface of the water in the reactor basement and 0.1 r/8 hours in the storage area.

Inasmuch as the chemical process plant will not be completed until several months after the MTR reactor is in operation, it became necessary to reevaluate the storage space for the spent fuel assemblies. Working on the assumption that the reactor will be in operation by January 1, 1952, the chemical plant by August 1, 1952, 300 assemblies and 50 shim rods will require storage. The length of the canal had been planned for storing 68 assemblies and 27 shim rods. To provide storage for the additional assemblies and shim rods it was necessary to extend the length of the canal 25'6".

The lengthened canal will extend 87'6" beyond the reactor building wall. The section of the roof which will extend under the road will be reinforced to accommodate heavy trucks and the motor crane used for removing the spent fuel assembly coffins. The unloading hatch will be located near the center of the road so that a minimum of vehicle movement will be necessary for the unloading operations. That portion of the canal roof designed for heavy loading will be separated from the remainder of the roof by means of curbing. This curbing will extend along both sides of the road for 50 feet on either side of the canal. This will prevent vehicles from traveling on the lightly constructed portion of the canal roof.

2.32 Recent Developments in Canal Design

Blaw-Knox would not guarantee a leak proof canal if constructed of normal reinforced concrete. There was some concern that cracks would develop and that radioactive water seeping through might create a problem. To overcome this it was decided to use a waterproof membrane in the canal construction.

Also, it had been recommended that the inside surfaces of the canal be such that good visibility will be obtained. Painting the surfaces was rejected since peeling and blistering will take place. White tile surfacing was considered; however, this is not only costly but there is no guarantee of good adherence of tile to concrete. Blaw-Knox had suggested using a layer of white cement. Using a thin layer is not advisable since spalling will take place. To make the entire wall thickness of white cement would be expensive. To solve the problem, the side walls and the floor of the canal will consist of ordinary reinforced concrete, a waterproof membrane, and four inches of white cement on the inside.

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The canal parapets extend three feet above the basement floor. The parapet wall thickness will be ten inches. A lip extending three inches beyond the wall thickness will be added to create a sense of security to anyone leaning over the parapet. This will make the top of the parapet 13 inches thick.

The walkway around the canal will slope slightly towards the parapets to allow drainage of any water that may drip from objects removed from the canal. At least three drains will be provided on each side of the canal.

2.33 Canal Mechanical Equipment Design Progress

Blaw-Knox has completed three preliminary designs on equipment for handling discharged assemblies from the reactor. All three designs are workable proposals. Efforts will be concentrated toward completion of the most reliable design after evaluation of the units.

Similarly the canal saw has been under study from several design viewpoints and a final design will be selected shortly.

The storage racks for the canal have been revaluated from the standpoint of concentration of fissionable materials, general construction, and cost. As a result a relatively inexpensive design holding 28 assemblies, either complete or sawed-off, has evolved.

2.4 Experimental Facilities and Services

2.41 Service Facilities

The types, sizes and availability of the services to the experimental facilities have been established. The main beam holes and the horizontal through hole will be provided with demineralized water, auxiliary soft water, spare liquid line, "warm" liquid drain, compressed air, spare gas line, "hot" gas exhaust, electrical outlets, spare conduits and telephone. These services will either be required at or available to each experimental hole. The contractor is currently working on the piping layouts, trenches and valve cubicles for these services.

2.42 Graphite Requirements for Dummy Plugs-

The graphite sections of the dummy plugs will be fabricated from GBF grade graphite. This grade of graphite is currently available in 4 1/2" x 4 1/2" x 50" block sizes. Allowing for machining waste, the total minimum requirement is 450 blocks or approximately 28,000 pounds. A list of the graphite requirements for each facility has been prepared and submitted for procurement.

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2.43 Beryllium Requirements for Dummy Plugs

There are only seven plugs that contain beryllium. These are HB-1 to HB-6 and HT-1 plugs. The total quantity of beryllium contained in these plugs is approximately 1.65 cu. ft. or 189 pounds. Drawings of the rough blanks have been prepared and submitted for procurement.

2.44 Flow Sheet Approvals

Flow sheets regarding experimental facilities have been prepared by the contractor. These flow sheets incorporate the service facilities and the associated piping, valves and control for each experimental facility. Preliminary approvals have been made subject to minor changes. Final approval is expected in the near future.

2.5 Water Systems

During the past quarter a revaluation of the water systems was made in the light of Sheppard T. Powell's consultation report. The number and type of process instruments were established and comments were made upon several flow sheets and numerous specifications.

2.51 Water Supply

The first well was drilled to a depth of 600 feet, reaching the water table at 456 feet. Over a one-day period a drawdown of only 0.5 feet occurred at a flow of about 1,100 gpm. The second well was still being drilled at 265 feet with difficulties occurring due to cave-ins and consequent loss of tools. The well pumps have not yet been installed, nor have water analyses been made on the well water while pumping at operating capacity.

A survey of local Idaho practice indicated it is safe to ground static electricity from motor-powered equipment to water lines and wells, as well as to ground mats and rods, so this practice will be adopted for the MTR.

Over-all reductions in soft, demineralized and cooling tower make-up water requirements have diminished the well water demand to about 600 gpm. Thus, one well can continually fulfill the site demand. As a result, one of the three wells has been eliminated leaving two wells to take care of supply and reserve. Likewise, the ground storage reservoirs were reduced to 66% of their previous value, or to two 500,000 gallon tanks.

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2.52 Water Treatment

As a result of ANL and Blaw-Knox re-estimates and the recommendations of S. T. Powell, the zeolite water softening system was reduced to 60 gpm, with subsequent blending of raw water to yield a total capacity of 75 gpm at 50 ppm hardness. The softened-blended-water hold-up storage tank was reduced to a capacity of 10,000 gallons, or about a two-hour supply. The demineralized-water storage tank was placed on ground level for economic reasons, and any back-up of radioactive waters will be detected by radiation alarms. Two 1,000-gpm and two 160-gpm pumps will deliver water from the demineralized-water storage tank. The softening and demineralizing plant specifications were made more rigid following the recommendation of S. T. Powell, and the demineralization plant capacity was set at 150 gpm at 6 gpm/sq.ft. throughput. The dilute acid for the neutralization of the cooling tower make-up water will be prepared batch-wise.

2.53 Process Cooling Water

The bids on the flash evaporators were evaluated, and the Graham Company was chosen as fabricator for all stainless steel units. The seal tank was reduced to 20,000 gallons, which still provides adequate reactor shutdown cooling.

Water conductivity and pH will be recorded continuously in the process water stream. The pH of the water will be maintained by means of the 50 gpm purge and make-up. This represents a turnover of about one-fourth the total volume of the process water system each day.

Although the process water piping layout in the reactor structure and building have been approved, Blaw-Knox has not yet justified the thermal, structural and supporting pipe stresses.

2.54 Secondary Cooling Water

A study by Blaw-Knox indicated that four 3,140 gpm, 100-foot head (three operating) vertical circulatory cooling tower water pumps gave the most economical arrangement. S. T. Powell's recommendations on cooling tower corrosion control were expanded to include a two-point pH recorder - one on the inlet acidified make-up water, and the other on the circulating cooling water. There will be manual adjustments on the flow-controlled dilute-acid proportioning pump. The 100 gpm canal effluent will be conserved by re-use as part of the cooling tower make-up.

2.6 Effluent Control

2.61 Retention Basin

ANL Design Report No. 47, "MTR Site Decay Retention Basin," was issued as a guide for Blaw-Knox in preparing designs for flows, layouts and construction drawings.

2.62 Effluent Pond

In view of the estimated large volume of water effluent and the high cost of the gravel bed due to a below-ground permeability of only 2.32 gpd/sq.ft. at the MTR site, a revaluation and rerouting of effluent flows and the utilization of an open pond appeared most feasible. Permeability tests conducted by the Twin City Testing and Engineering Laboratory gave a rate of 2.3 gallons per day per square foot. The effluent from the MTR amounts to 175 gpm. These figures determine the area of the pond to be 100,000 sq. ft. The normal volume of the pond will be about 250,000 gallons.

2.7 Air Exhaust Systems

The air exhaust systems of the MTR comprise that group of facilities which collect, process and dispose of all radioactive air that requires dispersal into the atmosphere through the main stack. Two separate systems, the external reactor-cooling air system and the contaminated air system, lead to the fan house and discharge into a common duct leading to the stack. The design of these systems was discussed in the preceding quarterly report. Several changes in and additions to the designs are dealt with in the following sections.

A study of instrumentation of the air systems has been made. This is presented in a separate section devoted to instrumentation alone.

2.71 External Reactor-Cooling Air System

The external reactor-cooling air system consists of that part of the reactor-cooling air system through which the air passes after it leaves the reactor structure.

The two exit air ducts within the reactor structure connect to a single duct below the basement floor. This duct, which conducts the air to the fan building, had been designated as a four-foot-square poured-concrete duct. Recent cost estimates by Blaw-Knox showed that concrete pipe would be more economical than the poured-concrete duct. This verified previous concepts held by ANL, and since round concrete pipe is entirely satisfactory in other respects, it will be used in place of the square poured-concrete duct.

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The discharge filters have been eliminated from the reactor air system. Whether filters are or are not necessary in the reactor air discharge line had been one of the chief controversial issues in the design of the reactor-air system. Based on experience with their respective reactors, personnel at ORNL believe filters are necessary, while personnel at Chalk River believe they are not necessary. The decision to omit filters was instigated chiefly by economy measures. Since the hazard, if any occurs, will not be immediate but rather a long-term effect, the omission of filters will not seriously influence early reactor operation. However, space will be provided for the addition of a filter building and equipment in the event they become necessary in the future.

The number of shutdown fans to be used has been increased from one to two. The shutdown fans provide sufficient flow of air through the reactor to provide adequate cooling during normal and emergency shutdowns. Each fan will be capable of delivering 5,000 cfm against a head of approximately two inches of water. In the previous design, the single fan had a dual drive which consisted of an electric motor and a gasoline engine. In the present design one fan will be driven by an electric motor and the other by a gasoline engine. In the event of failure of the motor-driven fan, the gasoline engine-driven fan will automatically take over. The additional cost, if any, of the new design will be very small, and the additional safety and flexibility warrants the change.

2.72 Contaminated Air System

The contaminated air system will remain essentially as presented in the last quarterly report. The recent decision to omit the tee portions of the reactor building wing reduced the number of laboratories, and therefore reduced the number of off-gas openings initially required to about 24. However, the capacity of the contaminated air system will not be changed, as it is based on the probable future need for 80 off-gas openings.

2.73 Fan Building

The elimination of discharge filters from the reactor air system eliminated the necessity for filter cells in the filter and fan building. This resulted in a considerable reduction in the cost of this building and its designation has been changed from "Filter and Fan Building" to "Fan Building."

2.74 Stack

The stack will serve to eject the radioactive gases into the atmosphere at an altitude sufficient to assure that exposure to these gases will not exceed tolerance anywhere on the site. The size of the stack has recently been approved by the Steering Committee. The height of the stack has been set at 250 feet. The inside diameter at the top has been set at

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five feet, based on a flow of 80,000 cfm at an exit velocity of 4,000 fpm. The material will be concrete.

Calculations for the stack height problem were made using Sutton's diffusion formula and several geometric interpretations. In consideration of the results of these calculations along with some experimental results and operational experience, it was concluded that a height of 200 feet would be tolerable but that a stack-height of 250 feet would be more desirable.

The main items involved in the determination of the stack diameter were the exit velocity and the capacity. The normal air flow up the stack for the present design will be about 40,000 cfm. The probable future flow up the stack will not exceed 80,000 cfm, for which an exit velocity of 4,000 fpm can easily be tolerated. The five-foot diameter based on these conditions gives an exit velocity of 2,000 fpm for the present design. This exit velocity is sufficient to prevent "downwash" of the radioactive gases to a level where they would mix with the turbulent air around buildings. "Downwash" is a term given to stack gases which are drawn down the vertical vortices formed in the lee of a stack. If the vortices bring the gases down far enough so they enter the turbulent region produced by buildings, the gases will be distributed in the air near the ground. Thus, the exit velocity for the present design is high enough to eliminate high activities at ground level due to this phenomenon.

2.8 Electrical Systems

The design of the electrical systems for general power and lighting, and for control, instrumentation and alarm requirements is progressing satisfactorily. Current problems entering into the design include the reliability of the supply of electrical energy, the distribution thereof to the points of use, and appropriate grounding arrangements.

2.81 Reliability of Incoming Power

The presently available power service in the Idaho Falls-Pocatello area has been somewhat unsatisfactory to industrial users in that area to date. This adverse condition has been caused by frequent power outages and relatively poor voltage and frequency regulation as compared to similar service in the large industrialized areas in the eastern and central parts of the country.

The service is being improved by the power companies with the installation of new lightning arrestor gear and switch gear; however, even with the expected improvement in reliability of service and reduction of power outages it is not likely that the systems now in use in the Idaho Falls-Pocatello area could be relied upon for power supply to the MTR.

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With the installation of the 132 KV Hi-Line from the Goshen sub-station to the Reactor Testing Station, good reliability of service is expected. The power companies have given every assurance that the service to the site will be reliable. At some time in the future a second 132 KV line will be added to provide power from the American Falls generating station.

2.82 Power from RTS Central Sub-station

There has been no change in the original loop plan for provision of electrical power to the MTR site from the RTS sub-station. However, the ultimate plan has been deferred to the extent that the immediate construction will provide only one side of the area loop feeder. When the locations of other reactor sites are determined in the RTS area, the loop feeder will be completed so that the MTR may receive power from either direction over the loop. This area feeder will operate at 132 KV under supervisory control from the RTS sub-station.

2.83 Power from Emergency Unit

There has been little change made in the plan for installation and operation of the local diesel electric standby unit which will provide emergency power for the processes and facilities that must operate during shutdown of the reactor. This unit is to be installed in the steam plant and provided with means for automatic starting, initiated by interruption or low voltage in the utilities power. This system is being designed for very fast starting so that the emergency power may be available with the least possible delay. The size of the unit is 600 KW at 80% power factor. At present a load of 350 KW will be required for operation during an emergency but the connected and starting loads are considerably greater. A dispatch control system will permit additional loads up to the full capacity of the unit.

2.84 Power from Storage Batteries

Several storage battery installations required for different services are located in certain of the MTR area buildings. The power from these batteries will be used directly as D-C in most instances. The main exception is the battery installation included in the reactor control and instrument power system. In this system A-C power for reactor control and instrumentation is obtained from two independent A-C busses. Each of these busses receives power from a motor generator inverter set operating from a D-C bus associated with the battery. One or more motor generator converter sets operating continuously from the utilities power system will provide power to the D-C system and maintain the battery in a floating status.

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Other storage batteries located in the steam plant and the electrical sub-station are required for control purposes. The Security Building will have two storage batteries - one for operation of the PABX telephone equipment, and the other for operation of radio, security and fire alarm equipment for the entire MTR site.

In all of these battery installations, with the exception of the electrical sub-station, provision is made for charging the batteries from the emergency system in the event of an interruption in the utilities power.

2.85 Primary Site Distribution

The primary distribution system will provide electrical power through double feeders to a number of load centers strategically located within the site. Although the present or initial RTS electrical distribution does not provide a double feeder system to the MTR electrical sub-station, it is planned to provide the double feeder system within the site in order to facilitate operation and the inspection of switch gear.

2.86 Secondary Site Distribution

Secondary distribution within the site provides for the distribution of power from the load centers to the points of use within the buildings. It is not planned to extend the double feeder system to secondary distribution. Power from the load centers will include both the utilities power and power from the emergency unit. Arrangements are planned wherein automatic switch gear located at the load centers and at the transformer stations within the buildings will transfer the required portion of the normal electrical load to the emergency units when necessary.

2.87 Electrical Grounding

As in any electrical installation, it is planned to provide for protection against electrical hazards. In addition to the electrical hazard grounding systems, the MTR requires radio frequency grounding arrangements throughout the reactor building and the laboratory wing in order to eliminate possible interference to electronic instruments.

The electrical hazard grounding arrangements will provide suitable grounds for power circuits, lightning, and static discharge. It is planned to use the two water well casings as zero ground reference. Since the locations of these wells are comparatively remote from many of the buildings and electrical installations in the site, it is planned to use additional grounding means in the form of grids. These grids, composed of buried mats or driven arrays of grounding rods, will be used at the electrical sub-station, elevated objects, such as the high stack and the water towers and other locations where electrical surge absorption is required.

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It is essential that each grid be cabled directly to zero ground reference. The usual grounding cables will be used to bond the steel of each building together and also be run directly to the zero ground reference.

Radio frequency grounding must essentially convert the reactor building and wing into a Faraday cage. In order to accomplish this, it is planned that there will be a single common ground reference throughout these buildings which will be obtained by bonding together all metallic members of the building and the neutrals of the incoming power services. Varying potential gradients must be minimized by elimination of electrical resistance variations between adjacent metallic members in the building. All reinforcing steel will be bonded to the common ground. Insofar as possible, the intersections of reinforcing steel bars and other metallic objects will be held securely together.

2.9 Instrumentation

There are three major instrumentation systems in the MTR Project: 1) reactor control; 2) the process air and water cooling systems; and 3) radiation monitoring. The first two systems have safety provisions and interlocking means to automatically indicate or stop unsafe operations. The design problems consist of the development of the instrument control centers and working out the detailed peculiarities of the numerous systems.

An over-all process instrumentation flow sheet has been prepared. Each instrument has been described as to the scope of its primary function, and to this extent the system has been relatively fixed for design and specification purposes. However, considerable work is still required on the interlocks.

The philosophy has changed from one of centralization of all these systems in one control room to a dual arrangement. Control of the reactor will be centered at the reactor control room on the third floor of the reactor building; the reactor cooling air and reactor cooling water systems will be controlled from the process water building. This is in compliance with a recent ORNL philosophy that instrumentation and the control of the major cooling processes from the reactor control center would not facilitate the operation and control of the reactor itself and should be separated.

2.91 Reactor Control Instrumentation

The reactor will be operated by a combination of manual and automatic controls. These will be under the supervisory control of systems of interlocks associated with both the reactor neutron instruments and the major cooling process instruments.

The size of the control room and the layout of the panels and console will be governed primarily by the requirements of the neutron controls and instruments. In addition, certain thermal indications and the basic indication and recording of thermal energy removed from the reactor by the water cooling process will be provided.

2.92 Process Control Instrumentation

The process control room will have central instrumentation and control for the reactor air and water cooling systems. Also, through interlocking means, a group of controls will limit automatically the startup and the operating levels of the reactor to safe operating conditions of the cooling systems.

Other instrumentation and control devices will provide for control and conservation of cooling water reserves during emergencies when the reactor is shut down due to interruption of electrical power.

2.93 Radiation Instrumentation

Studies have been progressing toward the selection of suitable radiation instrumentation for the water and air cooling systems. These studies have included the type of alarm system required to indicate back-flow contamination, to signal the necessity for diversion of flow and to warn of excessive activity from the standpoint of personnel protection. Alarms from some of the activity monitors may be transmitted to instrument centers. Other alarms as well as the activity measurements will be located at the point of measurement only. In general, the measurements of the activities within processes will be indicated only while those of effluent discharge will also be recorded for reasons of legality.

3.0 ANALYSIS AND DEVELOPMENT

3.1 Depth of Water in Canal

The design exposure level for the canal is 0.01 r/8 hrs. in the reactor basement, and 0.1 r/8 hrs. in the fuel assembly storage area. The depth of water necessary to satisfy these requirements has been problematical because of the uncertain distribution of fission product photon energy and multiple scattering build-up in the thick layers of water. However, recent measurements of the radiation from fuel slugs of the X-10 pile at Oak Ridge through seven to eleven feet of water (ORNL-50-5-29 by J. A. Lane) provide a substantial basis for an increase in canal depth from seven to eighteen feet. Although measurements were taken at 30 minutes after shutdown, correlation of the results with information on hard gamma

activity of fission products and total delayed energy makes it possible to estimate the shielding requirements at longer decay times.

A six-inch clearance between the bottom of a vertical fuel assembly and the canal floor will permit an effective shield thickness of 14.5 feet when the depth of water in the canal is eighteen feet. Table I lists the anticipated exposure at the surface of the water in the canal from one fuel assembly. After six hours decay, the radiation level from a storage rack containing 28 assemblies will be below the 0.1 r/8 hrs. tolerance level established for the storage area.

The tabulated exposures are based on a total delayed gamma energy given by the statistical calculations of K. Way, and hard gamma yields determined from the γ -n reaction in heavy water (Physical Review 71, p. 573, 1947). Since the hard components do not follow the $t^{-0.2}$ decay law, they are considered separately and listed as a fractional part of the total energy.

In order to correct for multiple scattering in water, an effective absorption coefficient of $\mu/1.2$ is used.

Table 1
EXPOSURE AT SURFACE OF WATER
IN THE CANAL

Decay Time	Total Gamma Energy MEV/SEC/ASSEMBLY	% Hard Gamma (3 MEV)	Exposure from one vertical assembly under 14.5 feet water, in r/8 hrs.
20 minutes	4.8×10^{16}	17.5	0.015
30 minutes	4.4×10^{16}	15.4	0.012
6 hours	2.1×10^{16}	3.6	0.0025
1 day	1.3×10^{16}	1.0	0.001

3.2 Thermal Stress in Beryllium Plugs

The initial cooling arrangement proposed for the beryllium in the dummy plugs consisted of a central cooling hole with a water return provided by an annulus between the beryllium and aluminum casing. This choice was dictated in part by a desire to keep machining to a minimum. An analysis of the thermal stresses with this geometry showed that a stress

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of approximately 26,000 lbs/sq.in. at the central cooling hole could be expected. Since the tensile strength of beryllium is close to this calculated stress value, it was decided to alter the cooling geometry to provide a reasonable factor of safety. This has been done by redistribution of the cooling water through nine 3/16 inch holes. The stress is now calculated to be a maximum of 8,000 lbs/sq.in.

3.3 Water Activity

A tabulation of the radioactive elements that comprise the total specific activity of the process water was presented in the previous quarterly report for the MTR. In order to facilitate matters in the determination of the activity at various places in the water system, log-log plots (see Fig. 2 and 3) were made for each constituent and the resulting total activity. In these figures the time represents the flow time from the active lattice.

The activity at the seal tank which is located ~ 60 seconds flow time from the active lattice is comprised of N^{16} , O^{19} , Al^{28} , Na^{24} and Mg^{27} . The N^{16} isotope emits hard gammas of energies in the order of 6 Mev. The shielding up to this point of the recirculation system was dictated by the nitrogen activity. Thereafter, aluminum, magnesium, and sodium were considered.

With a total cycle time of 750 seconds the activity of the process water entering the retention basin is $\sim 4 \times 10^3$ dis/cc second. At this time sodium is the major contributor. With a retention basin capacity of 360,000 gallons and a 50-gpm purge, a 120-hour delay period will allow the sodium activity to decay within the maximum permissible concentration in water. In Fig. 3 the log-log plot shows that at ~ 120 hours the sodium activity is down to 10 dis/cc second or $\sim 0.27 \mu\text{c/liter}$. The maximum permissible concentration (M.P.C.) of Na^{24} in water as specified by the Chalk River Conference of September 1949 is $5 \mu\text{c/liter}$. The M.P.C. tolerance values used by U. S. Atomic Energy Commission projects up to 1949 was $0.5 \mu\text{c/liter}$. Considering sodium alone, the water as discharged from the retention basin is below tolerance. However, the activity of P^{32} , which is formed from the fast neutron (n, α) reaction on Cl^{35} , is $\sim 1 \times 10^{-4} \mu\text{c/cc}$. The maximum permissible concentration in water as specified by the above conference has been set at $2 \times 10^{-4} \mu\text{c/cc}$.

Assuming that the chlorine content of water is held within 1 ppm and that it is present as a chloride rather than a gas, the activated water leaving the retention basin is below tolerance by a factor of two.

The permissible concentration for S^{35} is $10^{-2} \mu\text{c/cc}$, and the specific activity due to S^{35} in the process water is expected to be of the order of $0.5 \times 10^{-4} \mu\text{c/cc}$.

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There is some concern as to the allowable concentration for the Fe^{55} and Ca^{45} in that the total combined effect for P^{32} , S^{35} , Fe^{55} and Ca^{45} may render the water unsafe for ingestion. This phase of the problem has been submitted for comment to the Radiological Physics Division.

3.4 Lateral Pressure Exerted by Graphite Balls

An experiment is being set up at Argonne to determine the lateral pressure needed at the bottom of a column of graphite balls to induce vertical displacement of the balls. This will be of assistance in the determination of the strength of the keying necessary to tie together the stacks of permanent graphite under thermal cycling.